Steering Committee Discussion on Scientist to Scientist Meeting on Mining Waste Issues
Issues Linked to Research Table
4/21/00 Draft

The following is a summary of the top 3 or 4 issues per main topic area, linked to available research or projects. To develop this summary, the folks noted below did the following effort:

-reviewed the issue table (attached); identified the top 3 or 4 issues per topic;

-wrote these top 3-4 issues into the left column of the new boil down table (attached below)

-reviewed the 'what's happening' table (attached); identified those projects relevant to each of the top 3-4 issues; write in the project numbers associated with relevant projects per issue in the right column of the new boil down table.

Topics:

1) Characterization/monitoring issues: Larry Eccles
2) Remote Sensing: Jim Lazorchak, Larry Eccles
3) Fate/transport issues: Rick Wilkin and Bob Puls
4) Control of releases from mining sites: Rick Wilkin and Bob Puls
5) Risk assessment issues: Ed Hanlon
6) Remediation and treatment issues: Diana Bless and Roger Wilmoth
7) Biological/ecosystem/environmental effects: Jim Lazorchak, Rick Wilkin and Bob Puls
8) Technical Transfer: Mike Bishop
9) Other Issues - Regulatory and non-scientific: Nick Ceto
10) Modeling and predictive tools: Rick Wilkin and Bob Puls

Notes:

-The issue table did not list modeling and predictive tools issues out; the only modeling issue i found, in my cursury review, is Need to make information from different risk and pollutant fate modelling efforts more transferable noted under the fate/transport column. We have not added a separate table for Modeling/Prediction. It may still be desirable to keep Modeling and Prediction as a separate category, but it would help if there were some consensus by what is meant here, i.e., geochemical modeling, hydrologic modeling, both?, prediction of AMD?, prediction of ecological impact?, etc.

-The issue table did not separate issues 9 and 10 noted below; these are grouped together in the technical transfer table. I've talkied with Nick about this and he's coordinating with Mike to prevent duplication of effort.

<u>1) Characterization/monitoring issues: Larry Eccles</u>

Top Sub-Issues:	**Relevant activities and products (number of item associated with each activity from the 'What's Happening' table provided if available)**

<u>Sub-Issue #1:</u> Need inexpensive methods to characterize metal migration from mining sites.	<u>Regional Activities and products past and present</u> <u>ORD activities and products</u> 1) Characterization of Mine Leachates and the Development of a Ground-Water Monitoring Strategy. EPA/600/R-99/007 Larry Eccles, ORD/NERL 2) Journal article, Assessing mine drainage water quality from mineralogic color and spectral reflectance, plus other internal reports, due over the next several years. David James Williams 703-648-4798 5) Long Term Dissolution Testing of Mine Waste EPA530-R-95-040-A 19) MacDonald, M. S., G. C. Miller, and W. B. Lyons. 1994. Water Quality in Open Pit Precious Metal Mines. University of Nevada, Reno. <u>Other organization's activities and products</u> <u>Major Contaminants of Concern (generally)</u> <u>Any Major Gaps in Research or Work?</u>
<u>Sub-Issue #2:</u> Need ground-water/vadose zone monitoring strategies that can provide early alert of potential contaminant migration before ground water is seriously impacted and regulatory standards are exceeded.	<u>Regional Activities and products past and present</u> <u>ORD activities and products</u> 1) Characterization of Mine Leachates and the Development of a Ground-Water Monitoring Strategy EPA/600/R-99/007 Larry Eccles, ORD/NERL <u>Other organization's activities and products</u> <u>Major Contaminants of Concern (generally)</u> <u>Any Major Gaps in Research or Work?</u>

Sub-Issue #3: Need reliable methods for sampling/analysis of mercury in water and in solids	Regional Activities and products past and present ORD activities and products Nothing listed Other organization's activities and products 196) Processes Controlling the Chemical/Isotopic Speciation and Distribution of Mercury from Contaminated Mine Sites Gordon E. Brown, Jr. Trevor R. Ireland, Mae S. Gustin, James J. Rytuba (collaborator), Daniel Grolimund, Christopher S. Kim Stanford University, Stanford, CA (Brown, Ireland, Grolimund, Kim), University of Nevada-Reno, (Gustin), U.S. Geological Survey, Menlo Park, CA (Rytuba) Major Contaminants of Concern (generally) Any Major Gaps in Research or Work?

2) Remote Sensing: Jim Lazorchak, Larry Eccles

Top Sub-Issues:	**Relevant activities and products (number of item associated with each activity from the 'What's Happening' table provided if available)**
Sub-Issue #1: No issues identified.	Regional Activities and products past and present ORD activities and products 20) Imaging spectroscopy of fugitive environmental contaminants. Terry Slonecker (PI), LEB/EPIC, 703-648-4289; David Williams, LEB/EPIC, 703-648-4798. 21.5) Assessing mine drainage water quality from mineralogic color and spectral reflectance. David James Williams (PI), LEB/EPIC, (703)-648-4798. 22) Butte Mine Waste Project, Activity IV, Project 15: Roger Wilmoth (513) 569-7509 22.5) Research and evaluation of various remote sensor platforms for the identification of mountaintop removal mining practices and potential environmental impacts. Mary J. Lacerte (PI), LEB/EPIC, 703-648-4137; Terry Slonecker (Co-PI), LEB/EPIC, 703-648-4289

3) Fate/transport issues: Rick Wilkin and Bob Puls

Top Sub-Issues:	**Relevant activities and products (number of item associated with each activity from the 'What's Happening' table provided if available)**
Sub-Issue #1: Fate and Transport in the Environment: There is a continuing need to better understand the geochemical factors that govern metal mobility in the environment. With respect to fate and transport issues, because of the multitude of contaminant transport issues and diversity of problem-solving approaches, it is desirable to break down discussion/research efforts among the principal transport media, e.g., air, surface water, ground water, sediment, and soil. In addition, there is growing interest in behavior of contaminants as they are transported across media boundaries, for example, ground water - surface water interactions.	Regional Activities and products past and present 24) Review of Surface Coal Mining Emission Factors (EPA454-R-95-007) 23) Modeling Fugitive Dust Impacts from Surface Coal Mining Operations (EPA454-R-96-002) ORD activities and products Other organization's activities and products Environmental Geochemistry of Sulfide Oxidation (ed. C. Alpers and D. Blowes) ACS Symposium Series 550 1992. Blanchard C., and Stromberg M. (1987) Acidic precipitation in southeastern Arizona. Atmos. Env. 21: 2375. Oppenheimer M., and Epstein, C. (1985) Science, v. 229: 2375. Major Contaminants of Concern (generally) As, Cd, Cr, Cu, Pb, Mn, Hg, Se, Mo, Ag, Bi, U, Zn, Ni, Co, Sb SO_4^{2-}, CN^-, H^+ Any Major Gaps in Research or Work? Need to conduct site specific water balances before mining activities begin. Fate and Transport should be dealt with on a contaminant-class or metal by metal basis, in order to evaluate the differing geochemical behavior of metals when exposed to similar environmental conditions.

Sub-Issue #2: Natural Attenuation of Inorganics: Attenuation of metal contaminants may be considered as the sum effect of geochemical and biochemical processes that result in the immobilization and sequestration of metal contaminants over some range of environmental conditions (e.g., Eh and pH). Sequestration processes include adsorption, exchange, and precipitation. Iron-bearing minerals including hydroxides (e.g., ferrihydrite), oxyhydroxides (e.g., goethite), and sulfides (e.g., pyrite) have been identified as important solid-phase components that remove metals from solution. Studies are on-going that explore the kinetic effects of nucleation and growth/transformation on metal uptake capacity by iron minerals. the 1) geochemical processes that control aqueous and solid phase metal speciation and 2) evaluate the most reliable methods and practices for sample collection, preservation, and characterization.	Regional Activities and products past and present ORD activities and products 83) Natural Attenuation; Ed Bates, ORD/NRMRL 89) Natural Attenuation of Inorganics During Metal Sulfide Formation (NRMRL, R. Wilkin) 90) Natural Attenuation of Arsenic in an Urban Industrialized Watershed (NRMRL, R. Ford) 91) Natural Attenuation by Iron (Hydr)oxides in Soils and Sediments (NRMRL, R. Ford) Other organization's activities and products US DOE, Sandia National Laboratory (P. Brady) Assessment of Natural Attenuation of Inorganic Contaminants Berger et al. (2000) Appl. Geochem., v. 15:655. Major Contaminants of Concern (generally) As, Cd, Cr, Cu, Pb, Mn, Hg, Se, Mo, Ag, Bi, U, Zn, Ni, Co, Sb, radionuclides SO_4^{2-}, CN^-, H^+ Any Major Gaps in Research or Work? Research is needed to sort out the geochemical behavior of specific metal contaminants (e.g., As, Hg) in specific environmental conditions (e.g., AMD-sediment interactions). Research is needed to evaluate the most reliable methods of sample collection, preservation, and characterization, especially new methods of in situ field characterization.

Sub-Issue #3: Geochemical Modeling: A number of geochemical modeling packages are available and designed to speciate dissolved components, calculate the degree of under- or super-saturation of a solution with respect to various mineral phases, and to evaluate mass transfer processes (e.g, PHREEQE, MINTEQA2, EQ/36, SOLMINEQ). A subset of these software packages was applied to successfully model the evolution of mine pit lakes (Bird, 1993). A conclusion of this study was that site-specific kinetic data are necessary to forward-model the evolution of pit lakes. There is a clear need for more applications of geochemical codes to mine waste sites. In addition there is a need to continue the development of equilibrium/kinetic models that include ground water flow, kinetic processes such as adsorption and mineral growth, and ground water – surface water interactions.	Regional Activities and products past and present ORD activities and products Other organization's activities and products Environmental Geochemistry of Sulfide Oxidation (ed. C. Alpers and D. Blowes) ACS Symposium Series 550 1992. 154) Geochemical modeling of mine pit water: An overview and application of computer codes (D. Bird, M.S. Thesis, U. Nevada, 1993) Tempel, R.N. et al. (2000) Geochemical modeling approach to predicting As concentrations in a mine pit lake. Appl. Geochem., v. 15: 475. Major Contaminants of Concern (generally) As, Cd, Cr, Cu, Pb, Mn, Hg, Se, Mo, Ag, Bi, U, Zn, Ni, Co, Sb SO_4^{2-}, CN^-, H^+ Any Major Gaps in Research or Work? Need to make information from geochemical modeling efforts transferable and useable.

4) Control of releases from mining sites: Rick Wilkin and Bob Puls

Top Sub-Issues:	**Relevant activities and products (number of item associated with each activity from the 'What's Happening' table provided if available)**

Sub-Issue #1: AMD Prediction: The severity of environmental threats imposed by acid mine drainage is a function of the ore/gangue mineral assemblage in the source material and the availability for reaction of water and dissolved oxygen. Because these factors are highly variable from site to site, current practices for predicting the potential for AMD are costly and methods are of questionable reliability.	Regional Activities and products past and present 30) Technical Document: Acid Mine Drainage Prediction (EPA530-R-4-036) December 1994 ORD activities and products Other organization's activities and products Minnesota DNR (1994) Mine Waste Drainage Quality Prediction (K. Lapakko) B.C. Ministry of Energy and Mines (1997) Draft Guidelines for Predicting of Metal Leaching and ARD at Minesites in British Columbia (W. Price) Major Contaminants of Concern (generally) As, Cd, Cr, Cu, Pb, Mn, Hg, Se, Mo, Ag, Bi, U, Zn, Ni, Co, Sb SO_4^{2-}, CN^-, H^+ Any Major Gaps in Research or Work? There is a need for a detailed evaluation of static and kinetic methods for acid mine drainage prediction. There is necessarily a strong tie between acid mine drainage prediction and Topic Area 1 that addresses Characterization and Monitoring Issues. Need to explore the extent to which EPA can identify and respond to the potential threat of a deteriorating tailings impoundment dam.

<u>Sub-Issue #2:</u> <u>Minimizing Releases:</u> Reducing the amount of acidity or contaminants released to the environment can be achieved in several ways. Source reduction can include the implementation of processes that lead to more complete extraction and beneficiation of ore components, thereby minimizing the concentrations of acid-producing minerals in tailings piles. Other practices, such as tails reprocessing, can lead to significant reductions in hazardous constituents that might be released to the environment. Source control also includes methodologies that act to prevent or minimize oxidation reactions at the surfaces of metal sulfides (surfactant addition), or by manipulating geochemical conditions so that fluids in contact with mine wastes are reducing rather than oxygen- or Fe(III)-rich.	<u>Regional Activities and products past and present</u> 29) Innovative Methods of Managing Environmental Releases at Mine Sites (EPA530-R-94-012) April 1994 27) Damage Cases and Environmental Releases from Mines and Mineral Processing Sites (EPA530-R-99-023) April 1998 34) CALFED Bay-Delta Program: Reduce Hg in rivers and estuary by source control at inactive and abandoned sites (J. Hillenbrand, Region 9) 31) Total Maximum Daily Load (TMDL) for mercury will be developed over the next few years for the Bay Delta, California, and reaches of the Humboldt River, Nevada (J. Hillenbrand, Region 9) <u>ORD activities and products</u> 50) Hydrostatic bulkhead with sulfate-reducing bacteria (NRMRL, Activity III, Project 13) <u>Other organization's activities and products</u> US DOE Federal Energy Technology Center (Robert Kleinmann) Source control at tailings piles <u>Major Contaminants of Concern (generally)</u> As, Cd, Cr, Cu, Pb, Mn, Hg, Se, Mo, Ag, Bi, U, Zn, Ni, Co, Sb SO_4^{2-}, CN^-, H^+ <u>Any Major Gaps in Research or Work?</u> Research needed to indentify the best practices for source control. There is a need to find more cost effective, long-term solutions for capturing AMD and for treating AMD in treatment facilities.

<u>Sub-Issue #3:</u> <u>AMD Production:</u> Acid mine drainage is caused by oxidative weathering reactions of metal sulfides that are contained in mine rocks and mine wastes. These acid waters are able to leach surrounding materials and mobilize metals that are generally insoluble at the near-neutral pH conditions typical of ground waters and surface waters. Current research (outside of EPA) is directed at understanding the specific surface reactions and reaction kinetics that control the dissolution of metal sulfides, especially iron sulfides (e.g., Rinker et al., 1997; Guevremont et al., 1998; Bonnissel-Gissinger et al., 1998). Another area of active research explores the role of bacteria in the production of acid mine drainage (e.g., Nordstrom and Southham, 1997). A better understanding of these abiotic and biotic processes may perhaps lead to techniques for minimizing or eliminating oxidation reactions at the surface of metal sulfides.	<u>Regional Activities and products past and present</u> <u>ORD activities and products</u> <u>Other organization's activities and products</u> Some examples: Bonnissel-Gisinger et al. (1998) Env. Sci. Tech., v. 32: 2839. Guevremont et al. (1998) Env. Sci. Tech., v. 32: 3743. Rinker et al. (1997) Am. Min., v. 82: 900. Nordstrom and Southam (1997) Reviews in Mineralogy, v. 35: 361 <u>Major Contaminants of Concern (generally)</u> <u>Any Major Gaps in Research or Work?</u>

<u>5) Risk assessment issues: Ed Hanlon</u>

Top Sub-Issues:	**Relevant activities and products (number of item associated with each activity from the 'What's Happening' table provided if available)**

Sub-Issue #1: Need a focus on contaminant-specific (e.g., lead, zinc, copper, aluminum, antimony, arsenic, cadmium, others) and/or exposure route/media-specific (e.g., air, surface water, groundwater, sediments, soil) issues, Mike Bishop, Region 8	**Contaminant Specific, risk-based only:** Lead: ORD activities and products 58 Other organization's activities and products 169, 181, 303 Zinc: ORD activities and products Other organization's activities and products 181, 281 Copper: ORD activities and products Other organization's activities and products Brown, V. M., et.al. Arsenic: ORD/NCERQA: 178, 183, 194, 197 Other: Tempel, R. N., et.al.; Galbraith, H., et.al.; LeJeune, K., et.al.; Cadmium: Other organization's activities and products 169, 181 antimony, aluminum: none **Media-Specific, all types of references (e.g., risk, treatment, etc):** Air: 4, 20, 105, 196, 210, Blanchard, C. L., et.al. Surface water: 40, 91, 183, 189, 193, 258, 259, groundwater: 1, 4, 40, 45, 84, 85, 87, 88, 174, 182, 183, 189, 228, 243, 244, 246, 248, 253, 254, 255, 258, 259, 260, 263, 271, 278, 339, 343, Stromberg(a and b), J. C., et.al. Sediments: 2, 71, 89, 90, 91, 115, 116, 150, 156, 195, 196, 203, 209, 210, 212, 223, 234, 302, 303, 317 Soil: 58, 59, 84, 85, 89, 90, 91, 99, 168, 171, 178, 181, 188, 189, 191, 192, 196, 199, 200, 201, 205, 207, 211, 224, 227, 238, 262, 265, 321, 342, Galbraith, H., et.al.; Kapustka, L., et.al.; LeJeune, K., et.al.;

<u>Sub-Issue #2:</u> What tools are available to help assess what should be the treatment requirements to achieve water quality and other standards in waterbodies within watershed settings (i.e., involving 60-80 mines within a watershed), Mike Bishop, Region 8	<u>Regional Activities and products past and present</u> <u>ORD activities and products</u> 2) Journal article, Assessing mine drainage water quality from mineralogic color and spectral reflectance, plus other internal reports, due over the next several years. 19) MacDonald, M. S., G. C. Miller, and W. B. Lyons. 1994. Water Quality in Open Pit Precious Metal Mines. University of Nevada, Reno. 21.5) Journal article, Assessing mine drainage water quality from mineralogic color and spectral reflectance, plus other internal reports, due over the next several years. 32) EPA Region 9 Humboldt River, Nevada Watershed REMAP project; will provide an extensive data base on water quality in the watershed 94) HISTORIC HARDROCK MINING: WEST'S TOXIC LEGACY, THE CRITICAL LINK BETWEEN WATER QUALITY AND ABANDONED MINE SITES 163) Water Quality in Open Pit Precious Metal Mines <u>EPA ORD-NCERQA Program</u>: 184) Evaluation of Natural Amelioration of Acidic Deep Mine Discharges for Watershed Restoration 194) Geochemical, Biological and Economic Effects of Arsenic and Other Oxyanions on a Mining Impacted Watershed <u>Other organization's activities and products</u> 258) Origin, Fate, and Transport of Organic Compounds in Surface and Ground Waters and Their Effect on Water Quality (USGS) 267) Research in Analytical Environmental Trace Element Chemistry and Its Impact on Water Quality (U.S. Dept. of Interior, USGS) Price J.G., et.al.; Brown, V. M., et.al.;

<u>Sub-Issue #3:</u> How to assess potential effects from eventual evapo-concentration of pit lakes and/or contaminant movement to groundwater, Mike Bishop, Region 8	<u>ORD activities and products</u> 115) Hill, B.H., et.al; 1997. The effects of elevated metals on benthic community metabolism in a Rocky Mountain stream. 116) A.T. Herlihy, et.al; "Quantifying the Regional Effects of Mine Drainage on Stream Ecological Condition in Colorado Rockies from Probability Survey Data - Results of EPA Region 8 REMAP Project." 120) Hill, B.H., et.al; 2000 Periphyton community responses to elevated metal concentrations in a Rocky Mountain stream. 122.1) Genetic Induction and Genetic Diversity in Fish. Specifically, "Metallothionein Gene Transcription as an Indicator of Metal Exposure in Fathead Minnows." Reddy, T.V., et.al; 122.3) Effects of metals on sites encompassing thousands of acres and hundreds of miles (Dale Hoff, Region 8) <u>EPA ORD-NCERQA Program</u>: 180) Developing Effective Ecological Indicators for Watershed Analysis Duncan Patten, Yellowstone Ecosystems Studies, et.al., 181) Fate and Transport of Heavy Metals and Radionuclides in Soil: the Impacts of Vegetation, A.P. Schwab, et.al; 194) Geochemical, Biological and Economic Effects of Arsenic and Other Oxyanions on Mining Impacted Watershed, Glenn Miller,.... 195) Mercury and Iron Biogeochemistry, Thomas Suchanek and Peter Richerson, Dale Manty, ORD/NCERQA 196) Processes Controlling the Chemical/Isotopic Speciation and Distribution of Mercury from Contaminated Mine Sites, Gordon E. Brown, Jr. et.al; 197) Arsenic Cycle at the Harvard Mine Pit Lake, Mother Lode Gold District, California, Stanford University <u>Other organization's activities and products</u>: 258) Origin, Fate, and Transport of Organic Compounds in Surface and Ground Waters and Their Effect on Water Quality (U.S. Dept. of Interior, USGS) 278) Long-term effects of surface mining on ground-water levels and quality in two small watersheds in eastern OhioSkousen, USGS 279) Manganese and effluent toxicity in acid mine drainage waters: effects on fishes and invertebrates (USDA) 281) Effects of anthropogenic factors on ecosystems supporting the Neosho madtom with emphasis on historic zinc-lead mining USGS 285) Effects of mining activities on wildlife (USGS) 286) Contaminant effects on fish in the Sacramento River from exposure to heavy metals in acid-mine drainage USGS 289) Sources, fate and effects of mercury in aquatic systems at Acadia National Park, ME, and Cape Cod National Seashore, USGS 307) Bioavailability and potential effects of mercury & other trace metals on biota in Plow Shop/Grove Pond, Fort Devens MA USGS 315) Evaluating the effects of environmental contaminants on populations, communities, and ecosystems USGS 320) Effects of organochlorine contaminants on reproductive success of herons in Baltimore Maryland (SGS 322) Effects of Temephos and Methoprene on Macro-invertebrates and Amphibian Larvae in Freshwater USGS Kiffney, P. M. and W. H. Clements. 1993. Bioaccumulation of heavy metals by benthic invertebrates at the Arkansas River, Colorado.

Sub-Issue #4: Need to characterize bioavailability of mine wastes and metals, Mike Bishop, Region 8	ORD activities and products 58) Activity II, Project 22- Phosphate Stabilization of Heavy Metals-contaminated Mine Waste Yard Soils 89) Natural attenuation of inorganics during metal sulfide formation EPA ORD-NCERQA Program: 178) Development of Chemical Methods to Assess the Bioavailability of Arsenic in Contaminated Media 201) Effects of Surfactants on the Bioavailability and Biodegradation of Contaminants in Soils Other organization's activities and products: 236) The distribution and bioavailability of metal contaminants in a mining impacted river, USGS 307) Bioavailability and potential effects of mercury and other selected trace metals on biota in Plow Shop and Grove Pond, Fort Devens, MA, USGS Marr, J. C., et.al.;

6) Remediation and treatment issues: Diana Bless/Roger Wilmoth

Top Sub-Issues:	**Relevant activities and products (number of item associated with each activity from the 'What's Happening' table provided if available)**

Sub-Issue #1: What is the feasibility/effectiveness of closing/isolating/reclaiming/stabilizing acid generating tailings or waste piles in a streamside setting?	ORD activities and products 47) Activity III, Project 10: Surface Waste Piles Source Control, Roger Wilmoth (513) 569-7509 49) Activity III, Project 12: Sulfate-reducing Bacteria Reactive Wall By injecting source control materials, Alva Daniel(513) 569-7693 51) Activity III, Project 14: Biological Barrier, Ivars Licis (513) 569-7718 52) Activity III, Project 15 Engineered Tailings Cap, Roger Wilmoth (513) 569-7509 55) Activity III, Project 19: Support to SITES Program In-Situ Mercury Removal, Ed Bates(513) 569-7774 81) Mercury stabilization, Ed Feltcorn 202 564 9422 EPA ORD-NCERQA Program: 175) Mixed Waste Stabilization/Solidification Demonstration Project. Tri Hoang202 564 9713 Key Words: *innovative grouts; injecting source control materials; in situ; microbial capping technology; material to stabilize the tailings pile; in situ mercury stabilization, permeable reactive barrier wall; uranium; solidification technologies; radionuclides* Major Contaminants: *acidic metal-laden water resulting from the influx of water through surface mine waste piles*

<u>Sub-Issue #2:</u> Need improved or new methods or technologies for storage/remediation of mine wastes	<u>ORD activities and products</u> 57) Activity III, Project 21 - Integrated Process for Treatment of Berkley-Pit Water; Diana Bless (513) 569-7674 59.1) Activity III, Project 24 - Improvements in Engineered Bioremediation of Acid Mine Drainage, Diana Bless (513) 569-7674 61) Activity IV, Project 2: Sludge Stabilization Roger 66) Activity IV, Project 5: Removal of Arsenic As Storable Stable Precipitates 68) Activity IV, Project 8: Pit Lake System 73) Activity IV, Project 14: Artificial Neural Networks as an Analysis Tool for Geochemical Data <u>Key Words:</u> *optimize costs; improve overall economics; improvements of bioremediation; sludge handling and disposal; stable for long-term storage in tailing pond environments; better understand the system as a whole; lead to new or improved remediation technologies; artificial neural network* <u>Major Contaminants:</u> *acid mine drainage; sludges generated by remediation; arsenic*

Sub-Issue #3: Need to develop treatment or source control technologies for acid or metals-rich drainage from small mines in remote regions	Regional Activities and products past and present ORD activities and products 22) Activity IV, Project 15: Remote Imaging Spectroscopy-Imaging Spectroscopy, Diana Bless (513) 569-7674 39) Activity III, Project 1: development of a treatment facility at one of these sites to treat acidic metal-laden water. 41) Activity III, Project 3: Sulfate-reducing Bacteria Demonstration; Roger Wilmoth (513) 569-7509 Key Words: *acidic metal-laden water, remotely located metals mine, source control technology, biological sulfate reduction, remote sensing, long term monitoring* Major Contaminants: *acidic metal-laden water* Any Major Gaps in Research or Work? (Note: these gaps apply to all three top sub-topic) 1) What tools are available to assess lower operation and maintenance options with high cost remedies? 2) In order to reduce costs when meeting water quality standards, what technical/other issues should be considered when considering options to bring in water from another watershed to increase stream flow? 3) Any case studies which involve a treatment train to a unit process to address/meet treatment standards for bio-sulfur? 4) Various post-mining land use issues, including minimum reclamation standards and bonding requirements.
Sub-Issue #4: Using case studies and additional research, need to identify effectiveness of plugging mine adits that discharge acid mine drainage to streams (which may be considered the most practical remedy in remote areas); catastrophic failure should be analyzed/halt production of acid drainage	Regional Activities and products past and present ORD activities and products 40) Activity III, Project 2: Clay-based Grouting Demonstration; Roger Wilmoth (513) 569-7509 45) Activity III, Project 8: Underground Mine Source Control; Roger Wilmoth (513) 569-7509 Key Words: *clay-based grouting, source control material, grout material (Hydro Active Combi Grout)* Major Contaminants: *acid mine drainage*

Sub-Issue #5: Need to understand environmental effects of land application of spent metal cyanide solutions	ORD activities and products 43) Activity III, Project 5: Biocyanide Demonstration, Roger Wilmoth (513) 569-7509 48) Activity III, Project 11: Cyanide Heap Biological Detoxification Pat Clark 513-569- 7681 62) Activity IV, Project 3: Photoassisted Electron Transfer Reactions Research, Roger Wilmoth (513) 569-7509 63) Photoassisted Electron Transfer Reactions for Metal-Complexed Cyanide, Roger Wilmoth (513) 569-7509 64) Photoassisted Electron Transfer Reactions for Berkeley Pit Water, Roger Wilmoth (513) 569-7509 Key Words: *cyanide, bio-detoxification of cyanide heaps, cyanide removal, destruction of cyanide, metal- complexed cyanides* Major Contaminants: *cyanide*

<u>The following additional Sub-Issues were identified, but the Steering Committee tentatively Do Not Plan to Discuss These at the 6/14-15 Meeting:</u> <u>Sub-Issue #6:</u> Need cost-effective technologies that treat acidic mine drainage and remediate metal concentrations in streams	<u>Regional Activities and products past and present</u> 80) Sacramento Sanitation District one million dollar study to develop a Sacramento River Toxic Pollutant Control Program that has mercury as one of its principle concerns; John Hillenbrand, Region 9 <u>ORD activities and products</u> 42) Activity III Project 4 Comparison of three technologies for the removal of nitrate from mine water; Roger Wilmoth (513) 569-7509 44) Activity III, Project 6: Pollutant Magnet; Roger Wilmoth (513) 569-7509 75) Activity III, Project 7: Arsenic Oxidation; Roger Wilmoth (513) 569-7509 46) Activity III, Project 9: Arsenic Removal; Roger Wilmoth (513) 569-7509 50) Activity III, Project 13 Hydrostatic Bulkhead with Sulfate-Reducing Bacteria; Roger Wilmoth (513) 569-7509 53) Activity III, Project 16 Integrated Passive Biological Treatment Process; Roger Wilmoth (513) 569-7509 54) Activity III, Project 18: Gas-fed Sulfate-reducing Bacteria Berkeley Pit; Roger Wilmoth (513) 569-7509 56) Activity III, Project 20 – The Selenium Removal/Treatment Alternatives Demonstration Project; Roger Wilmoth (513) 569-7509 65) Activity IV, Project 4: Metal Ion Removal From Acid Mine Waste Water by Neutral Chelating Polymers; Roger Wilmoth (513) 569-7509 72) Activity IV, Project 12: An Investigation to Develop a Technology for Removing Thallium from Mine Waste Waters; Roger Wilmoth (513) 569-7509 83) Natural Attenuation; Ed Bates, ORD/NRMRL 89) Natural Attenuation of Inorganics During Metal Sulfide Formation (NRMRL, R. Wilkin) 90) Natural Attenuation of Arsenic in an Urban Industrialized Watershed (NRMRL, R. Ford) 91) Natural Attenuation by Iron (Hydr)oxides in Soils and Sediments (NRMRL, R. Ford) 82) Acid Mine Drainage treatment; Ed Bates, ORD/NRMRL <u>Key Words:</u> *removal of nitrate; removing arsenic; arsenic oxidation;*

Sub-Issue #7: Need information on technical feasibility, regulatory acceptability and cost effectiveness	ORD activities and products 58) Activity III, Project 22- Phosphate Stabilization of Heavy Metals-Contaminated Mine Waste Yard Soils, Alva Daniels(513) 569-7693 60) Activity IV, Project 1: Berkeley Pit Water Treatment 67) Activity IV, Project 7: Berkeley Pit Innovative Technologies Project Key Words: *technical feasibility and regulatory feasibility; effectiveness; test bed for high risk/innovative technologies* Major Contaminants: *lead; acid mine drainage*
Sub-Issue #8: Need for research on use of organic soil amendments (compost/plant species) to remediate metal contaminated soils	ORD activities and products 59) Activity III, Project 23: Revegetation of Mining Using Organic Soil Amendments and Evaluate the Potential for Creating Attractive Nuisances for Wildlife, Ivars Licis(513) 569-7718 EPA ORD-NCERQA Program: 176) Phytoremediation of radionuclides by plants, ORIA HQ202 564 9379 Key Words: *improve soil conditions, reduce erosion, enhance plant establishment, and stabilize metals; phytoremediation for radionuclides* Major Contaminants: *metals; radionuclides*

<u>Sub-Issue #9:</u> Groundwater and Soils/Sediment Remediation (general issues)	<u>ORD activities and products</u> 84) In-situ remediation of contaminants in groundwater and soils, Robert Puls, ORD/NRMRL, 580-436-8543 85) Enhanced transformation and detoxification of chlorinated solvents and arsenic in groundwater and soils by zero-valent metals, Robert Puls, ORD/NRMRL, 580-436-8543 87) An in situ permeable reactive barrier for the treatment of hexavalent chromium and trichloroethylene in ground water, Robert Puls, ORD/NRMRL, 580-436-8543 88) PRB strategies and performance monitoring for remediation of inorganic contaminants, Rick Wilkin, ORD/NRMRL, 580-436-8874 89) Natural attenuation of inorganics during metal sulfide formation, Rick Wilkin, ORD/NRMRL, 580-436-8874 90) Natural Attenuation of Arsenic in an Urban Industrialized Watershed, Robert Ford, ORD/NRMRL, 580-436-8872 91) Natural Attenuation by Iron (Hydr)oxides in soils and sediments, Robert Ford, ORD/NRMRL, 580-436-8872 <u>Keywords:</u> *hexavalent chromium and selected chlorinated hydrocarbons; precipitation of arsenic species; chlorinated solvent compounds; arsenic and chromium; metal -rich solutions; iron sulfide formation; metal uptake; long-term stabilization of arsenic associated with Fe (hydroxides)* <u>Major Contaminants:</u> *hexavalent chromium; chlorinated hydrocarbons; arsenic; chromium; metal-rich solutions*

<u>7) Biological/ecosystem/environmental effects: Jim Lazorchak, Rick Wilkin and Bob Puls:</u>

Top Sub-Issues:	**Relevant activities and products (number of item associated with each activity from the 'What's Happening' table provided if available)**

<u>Sub-Issue #1:</u> Genetically resistent organisms; specifically, need to identify biologic communities that have adapted to naturally mineralized (Zn, Cd, Cu, Se, As) conditions. What is the feasibility of planting/adapting these communities in mining impact areas, and receipt of a special designated use under Clean Water Act?	**<u>Regional Activities and products past and present</u>** **<u>ORD activities and products</u>** 122.1) Genetic Induction and Genetic Diversity in Fish. Specifically, "Metallothionein Gene Transcription as an Indicator of Metal Exposure in Fathead Minnows." Reddy, T.V., Lattier, D.L., Lazorchak, J. M., U.S. EPA, Cincinnati, OH, Smith, M.E., SBI c/o U.S. EPA, Cincinnati, OH, and Toth, G.P., USEPA, Cincinnati, OH 122.2) Development and evaluation of an indicator of the condition and vulnerability of aquatic ecosystems based on the level of genetic homogeneity within populations of wide-ranging species. Dr Mark Bagley 513 569 7455
<u>Sub-Issue #2:</u> How to assess cumulative impacts to biological resources and ecosystems, and Surface and Groundwater Water Quality (Region 8 & 9)	98) Identification of factors influencing biotic response to acid mine /drainage and acid deposition in MAHA, Dr. Terry Flum, 513-569-7715 113) Mining impacts on fish assemblages in the Eagle and Arkansas Rivers, Colorado, McCormick, F.H., B.H. Hill, L.P. Parrish, and W.T. Willingham 116) Quantifying the Regional Effects of Mine Drainage on Stream Ecological Condition in the Colorado Rockies from Probability Survey Data - Results of the EPA Region 8 REMAP Project. A.T. Herlihy, J.M. Lazorchak, F.V. McCormick, D.J. Klemm, M.E. Smith, W.T. Willingham, and L.P. Parrish 117) The Role of Heavy Metals in Structuring Benthic Macroinvertebrate Communities in Colorado's Mountain Streams, Clements, William, H., Carlisle, D.M., Lazorchak, J.M. and Johnson, P.C. 120) Periphyton community responses to elevated metal concentrations in a Rocky Mountain stream, Hill, B.H., W.T. Willingham, L.P. Parrish, and B.H. McFarland 122.3) Effects of metals on sites encompassing thousands of acres; Dale Hoff, Ph.D. Region 8 Ecotoxicologist BTAG Coordinator & John Hillenbrand, Region 9

Sub-Issue #3: Environmental Effects: Multiple environmental problems arise from the interactions between mine wastewater and aquatic and terrestrial ecosystems. Fish and other aquatic life are the most adversely affected by low pH and the toxic effects of many dissolved metals, even at extremely low concentrations. In addition, surface water contamination can impair such water for municipal, recreational, livestock, and irrigation uses. Secondary impacts result from aesthetic degradation of wetlands and destruction of terrestrial habitats. The impact of acid mine drainage on aquifer quality is considered to be less consequential than for surface waters, although comparatively few data are available to access aquifer impact.	Regional Activities and products past and present 95) At the Carson River, Nevada Superfund site, work is on-going for looking at historical impacts of Hg contaminated mine tailings in Lahonton reservoir and wetland areas below the Lahonton dam (J. Hillenbrand, region 9). 94) Historic Hardrock Mining: West's Toxic Legacy, The Critical Link Between Water Quality and Abandoned Mine Sites (EPA908-F-95-002) ORD activities and products Other Federal organization's activities and products Environmental Impact Statements for Mesquite Mine (CA), Glamis Imperial Mine (CA), Powder River Coal Lease Application (WY), and the Thundercloud Coal Lease Application (WY), Bureau of Land Management USGS - The environmental impacts of mining and their mitigation (1991-004841) Other organization's activities and products Eary, L.E. (1999) Appl. Geochem., v. 14: 963. Soucek et al. (2000) Env. Tox. Chem., v. 19: 1036. Major Contaminants of Concern (generally) As, Cd, Cr, Cu, Pb, Mn, Hg, Se, Mo, Ag, Bi, U, Zn, Ni, Co, Sb SO_4^{2-}, CN^-, H^+ Any Major Gaps in Research or Work? What are the cumulative effects AMD on high elevation streams where 1) AMD enters and mixes with the stream, and 2) downstream where metals precipitate? What is the impact of AMD on ground water quality? What are the impacts on aquatic organisms of low pH, high turbidity, and the iron precipitates that coat surficial sediments of streams and lakes? Suggestion: Identify a small number of critically impaired watersheds on which to focus research efforts.

8) Technical Transfer: Mike Bishop

To Be Discussed

9) Other Issues - Regulatory and non-scientific: Nick Ceto

Top Sub-Issues:	**Relevant activities and products (for first three items underlined below, provide number associated with each activity from the 'What's Happening' table)**

Sub-Issue #1: Establishing closure performance standards. Historically mine closure has simply meant regrading and vegetation of mined areas. Actions to address potential long term environmental impacts were seldom included. Mine closure should be redefined to include appropriate short and long term performance standards to address environmental concerns.	Regional Activities and products past and present R10 - EPA and Hard Rock Mining: A Source Book for Industry in the Northwest and Alaska - Draft - 1999 ORD activities and products Other organization's activities and products 14) Technical Analysis and Evaluation of Mining Site Remediation Costs (not sure who wrote this) 17) EPA, Office of Solid Waste. 1994, Acid Generation Prediction in Mining. Draft. 30) Technical Document: Acid Mine Drainage Prediction, EPA530-R-94-036 184) Evaluation of Natural Amelioration of Acidic Deep Mine Discharges for Watershed Restoration, David A. Dzombak, William W. Aljoe Institution: Carnegie Mellon University Major Contaminants of Concern (generally) N/A Any Major Gaps in Research or Work? Yes, better tools for predicting long term impacts are needed. In addition, low O&M methods of managing long term water treatment needs are required.

Sub-Issue #2: Adequate financial assurance. Too often the financial assurance held for hardrock mines is inadequate to address environmental concerns at closure, particularly if the mine closes early, experiences unanticipated problems, or requires long term water treatment or other intensive management to meet environmental standards.	Regional Activities and products past and present Financial Assurances and Hard Rock Mining in Region 10 - Draft Issue Paper - August 1999 ORD activities and products Other organization's activities and products 27) Damage Cases and Environmental Releases from Mines and Mineral Processing Sites, EPA 530-R-99-023 Major Contaminants of Concern (generally) N/A Any Major Gaps in Research or Work? Consistent, protective and enforceable requirements are needed. Federal, tribal, and state agencies must coordinate their financial assurance programs. Research to support a uniform federal policy should be considered.

Sub-Issue #3: Establishing flexible environmental performance standards for addressing contamination in historic mining districts. The environmental problems posed by historic mining districts require a flexible approach to design and implementation of cleanup actions. Flexibility is establishing environmental performance standards would help to promote creative solutions to the AML problem.	Regional Activities and products past and present Abandoned Mine Site Characterization and Cleanup Handbook - Final Draft - March 2000 - USEPA ORD activities and products 83, 84, 88, 198 Other organization's activities and products 29, 180 Major Contaminants of Concern (generally) Any Major Gaps in Research or Work? Better information is needed to determine how to apply flexible environmental standards in historically mined watersheds where achievement of chronic water quality criteria is impracticable, but an alternate performance standard may be acceptable to meet most environmental goals.

Sub-Issue #4: Good Samaritan legislation. Concerns over liability often deter "Good Samaritan" parties from assisting in cleanup efforts in historic mining districts. Legislation to encourage Good Samaritan efforts to address environmental concerns should be promoted by EPA.	Regional Activities and products past and present ORD activities and products Other organization's activities and products 147 Major Contaminants of Concern (generally) N/A Any Major Gaps in Research or Work? Proposed legislation is pending. EPA may need to play a more active role in promoting appropriate provisions.

10) Modeling and predictive tools: Rick Wilkin and Bob Puls

We have not added a separate table for Modeling/Prediction. It may still be desirable to keep Modeling and Prediction as a separate category, but it would help if there were some consensus by what is meant here, i.e., geochemical modeling, hydrologic modeling, both?, prediction of AMD?, prediction of ecological impact?, etc.